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Lin

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(54) **APPARATUS AND METHOD FOR REMOTE CONVENIENCE MESSAGE RECEPTION WITH SIGNAL STRENGTH DETERMINATION**

(75) Inventor: **Xing Ping Lin**, Waterford, MI (US)

(73) Assignee: **TRW Inc.**, Lyndhurst, OH (US)

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(52) **U.S. Cl.** **340/825.69**; 340/3.55; 340/526; 340/825.72; 340/825.57; 340/825.65; 340/5.64

(58) **Field of Search** 340/511, 5.61, 340/825.69, 825.65, 3.55, 526, 10.1, 10.33, 10.4, 10.42, 572.1, 825.72, 825.57, 5.64, 5.72; 455/226.2, 134

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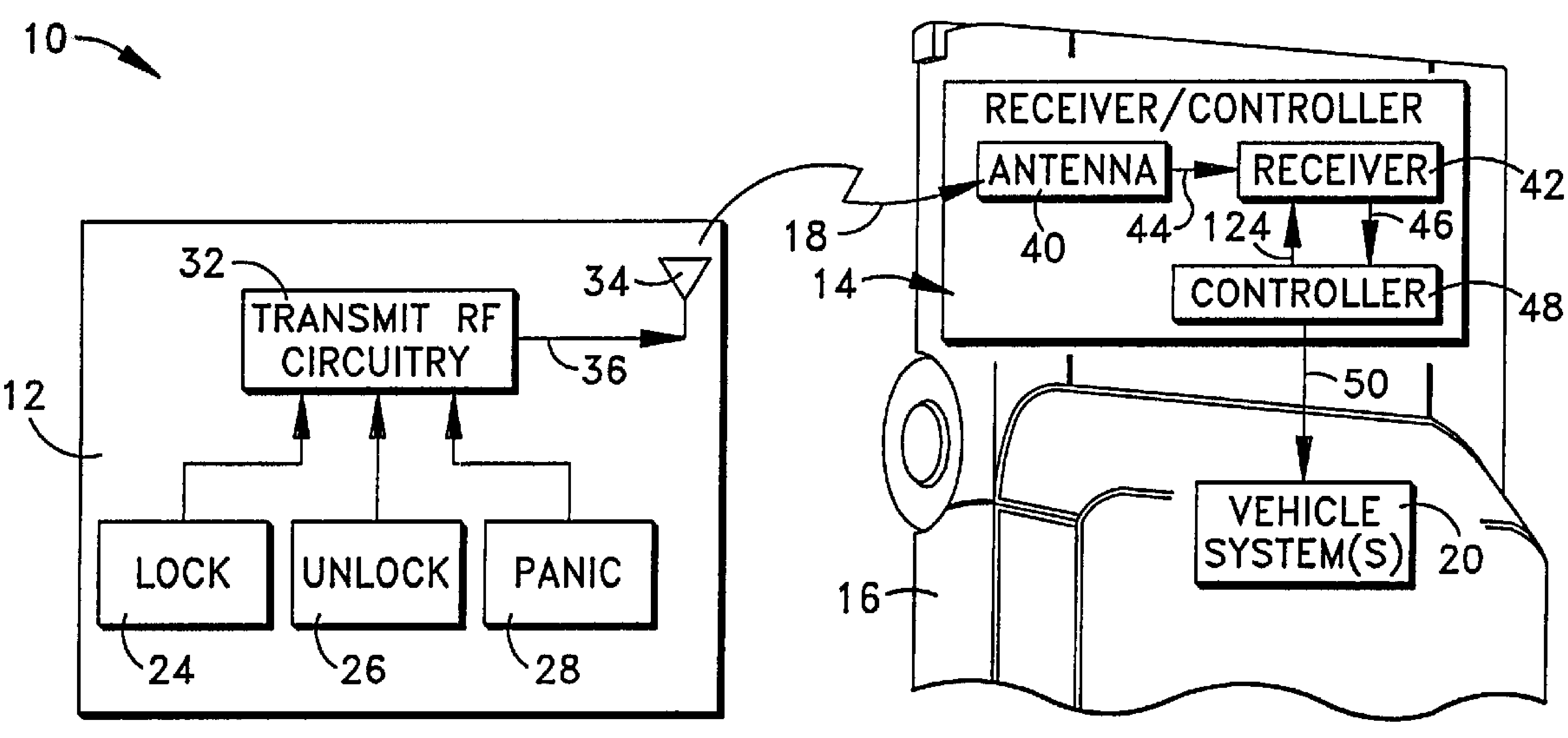
Primary Examiner—Michael Horabik
Assistant Examiner—Hung Dang
(74) *Attorney, Agent, or Firm*—Tarolli, Sundheim, Covell, Tummino & Szabo L.L.P.

(57) **ABSTRACT**

An apparatus (**14**) and an associated method determine signal strength of a received electromagnetic signal (**18**) that is comprised of a plurality of pulses that convey a remote convenience function request, and which causes performance of the requested function. A comparator (**82**) has a first input for receiving an electrical signal (**78**) with a voltage that varies to convey the remote convenience function request. A second input of the comparator (**82**) receives a threshold voltage value reference signal (**86**). An output of the comparator (**82**) provides an output signal (**46**) that indicates the occurrence of the voltage of the electrical signal (**78**) exceeding the threshold value of the reference signal (**86**). A microprocessor (**100**) and a threshold change trigger (**122**) of a controller portion (**48**) adjust the threshold voltage value of the reference signal (**86**). A microprocessor (**52**) and a count memory (**126**) of the controller portion (**48**) monitor the output signal (**46**) of the comparator (**82**) during adjustment of the threshold voltage value of the reference signal (**86**) to determine strength of the electromagnetic signal (**18**).

6 Claims, 4 Drawing Sheets



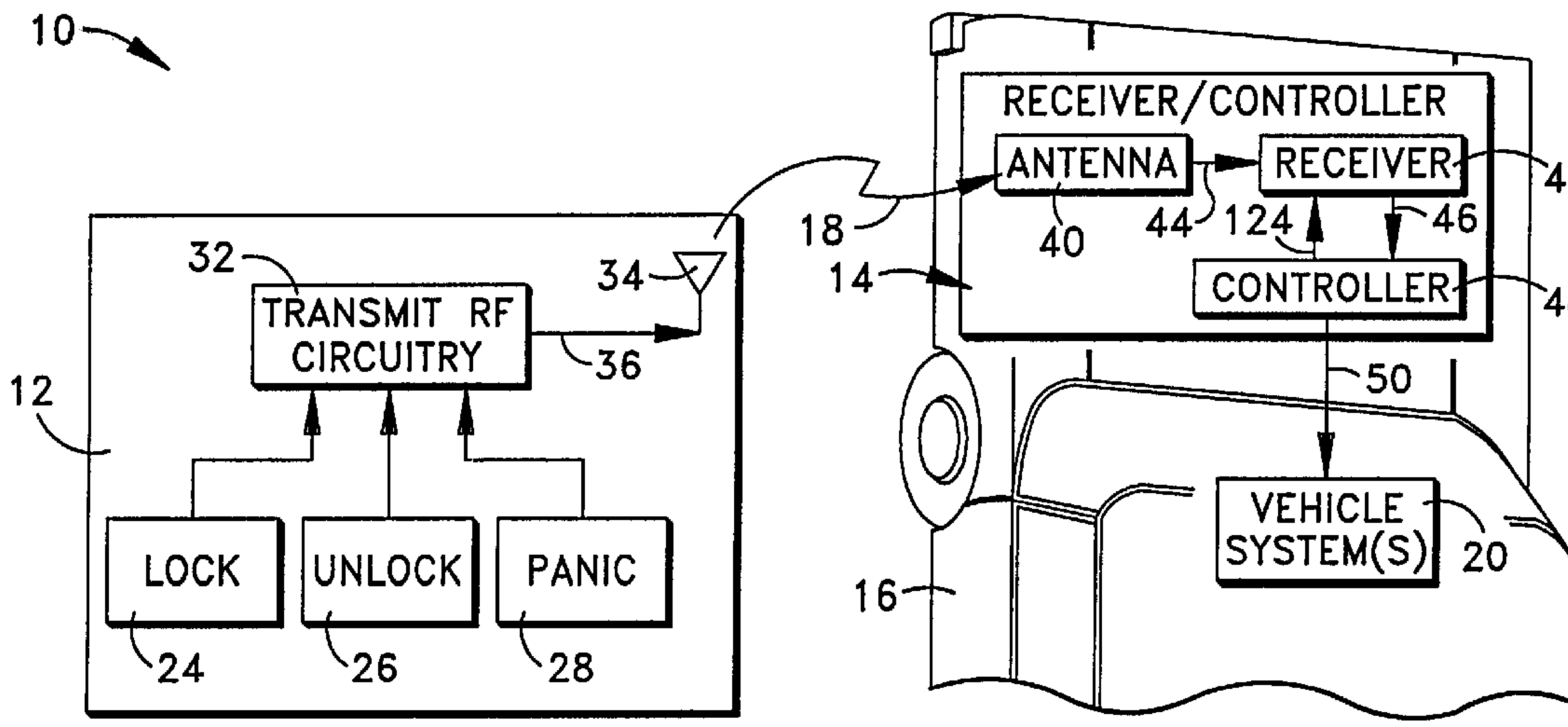

10
RECEIVER/CONTROLLER
ANTENNA
RECEIVER
42
18
40
44
124
46
14
CONTROLLER
48
32
34
TRANSMIT RF
CIRCUITRY
36
12
50
VEHICLE
SYSTEM(S)
20
LOCK
UNLOCK
PANIC
16
24
26
28

Fig.1

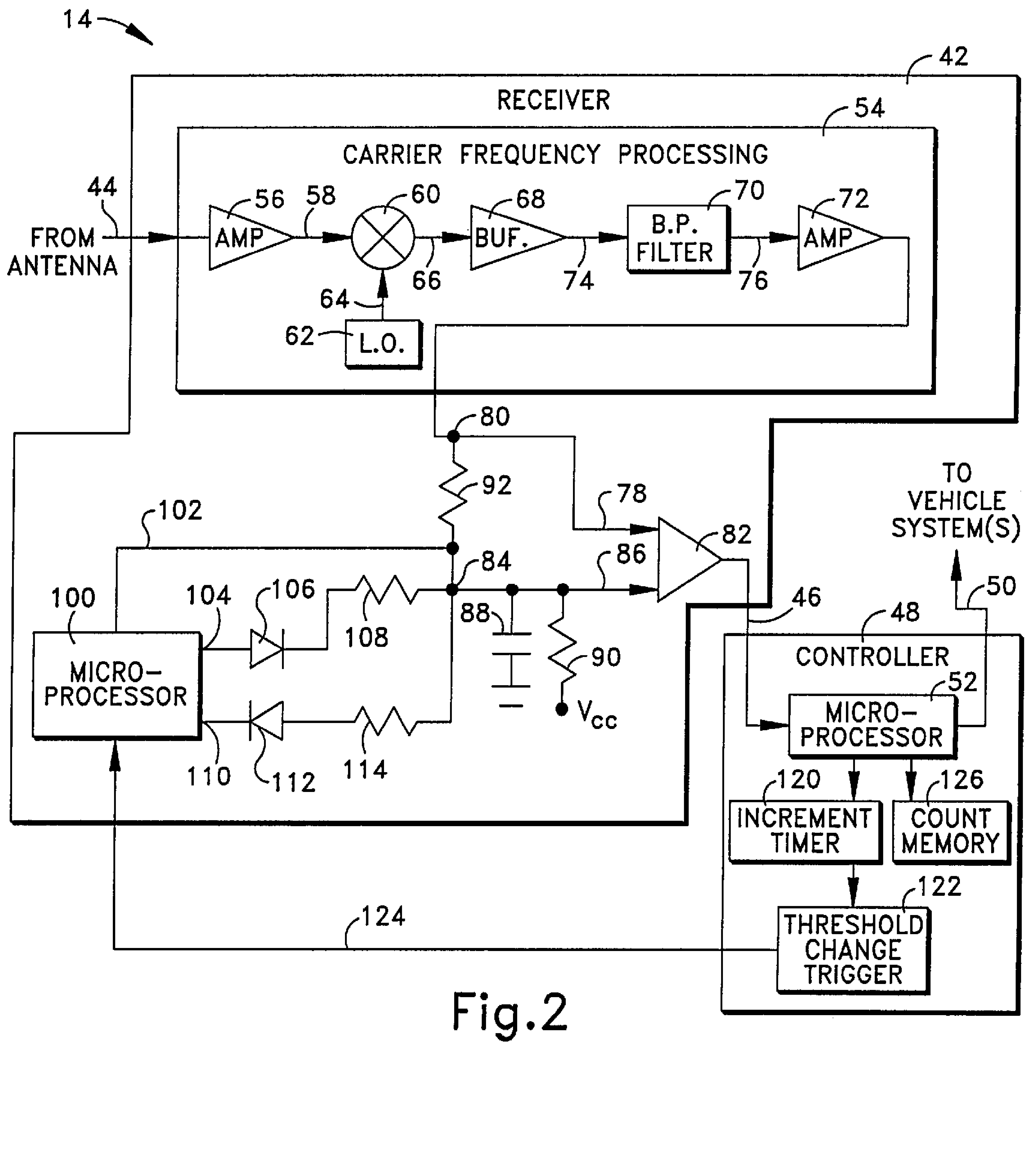

14
42
RECEIVER
54
CARRIER FREQUENCY PROCESSING
44
FROM
ANTENNA
AMP
56
58
60
BUF.
68
70
B.P.
FILTER
72
AMP
64
66
74
76
62
L.O.
80
92
78
102
82
84
86
100
104
106
108
46
TO
VEHICLE
SYSTEM(S)
50
88
48
MICRO-
PROCESSOR
90
CONTROLLER
52
V_{cc}
MICRO-
PROCESSOR
110
112
114
120
126
INCREMENT
TIMER
COUNT
MEMORY
122
124
THRESHOLD
CHANGE
TRIGGER

Fig.2

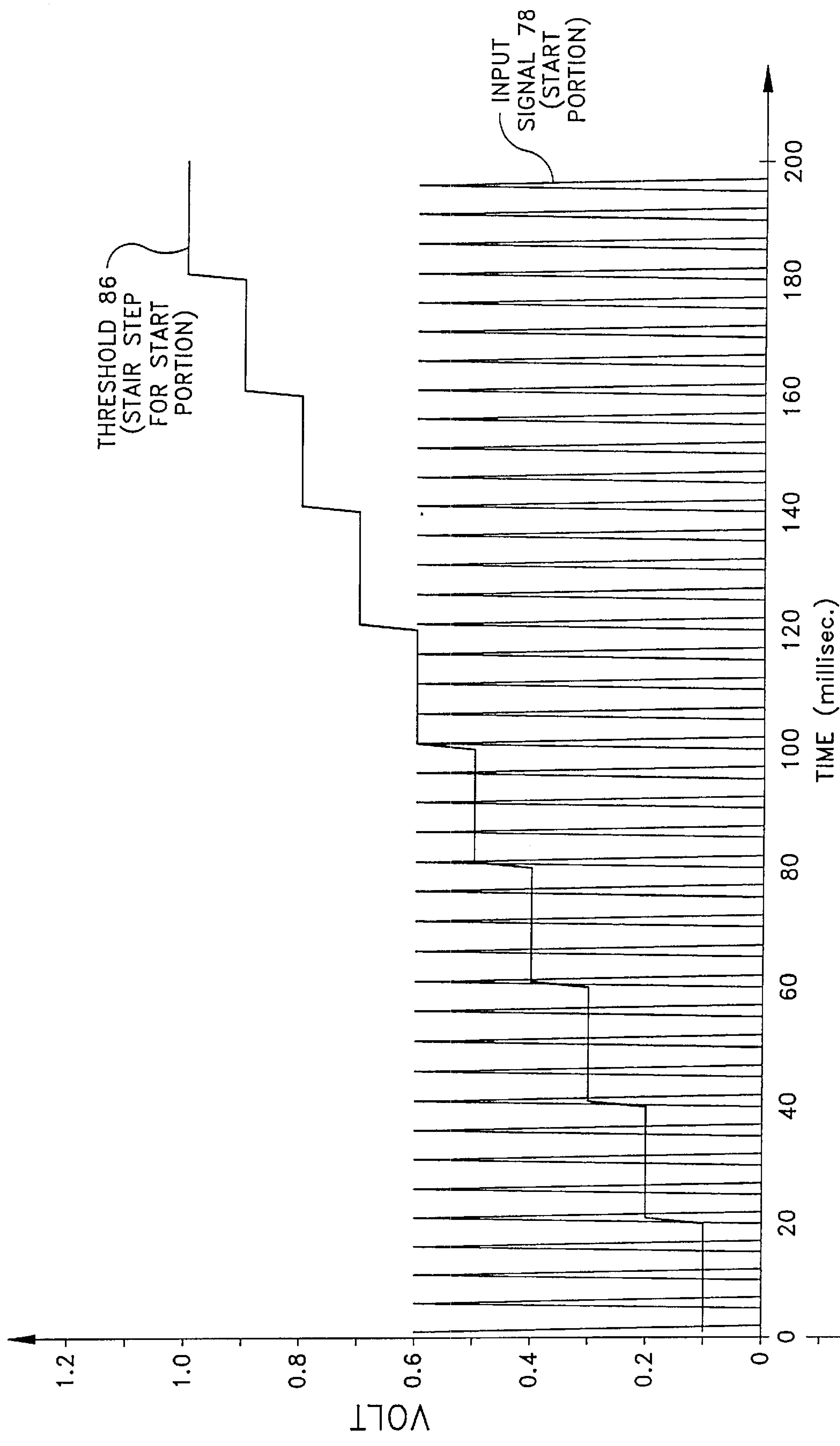

THRESHOLD 86
(STAIR STEP
FOR START
PORTION)
INPUT
SIGNAL 78
(START
PORTION)
VOLT
1.2
1.0
0.8
0.6
0.4
0.2
0
-0.2
TIME (millisec.)
0
20
40
60
80
100
120
140
160
180
200

Fig.3

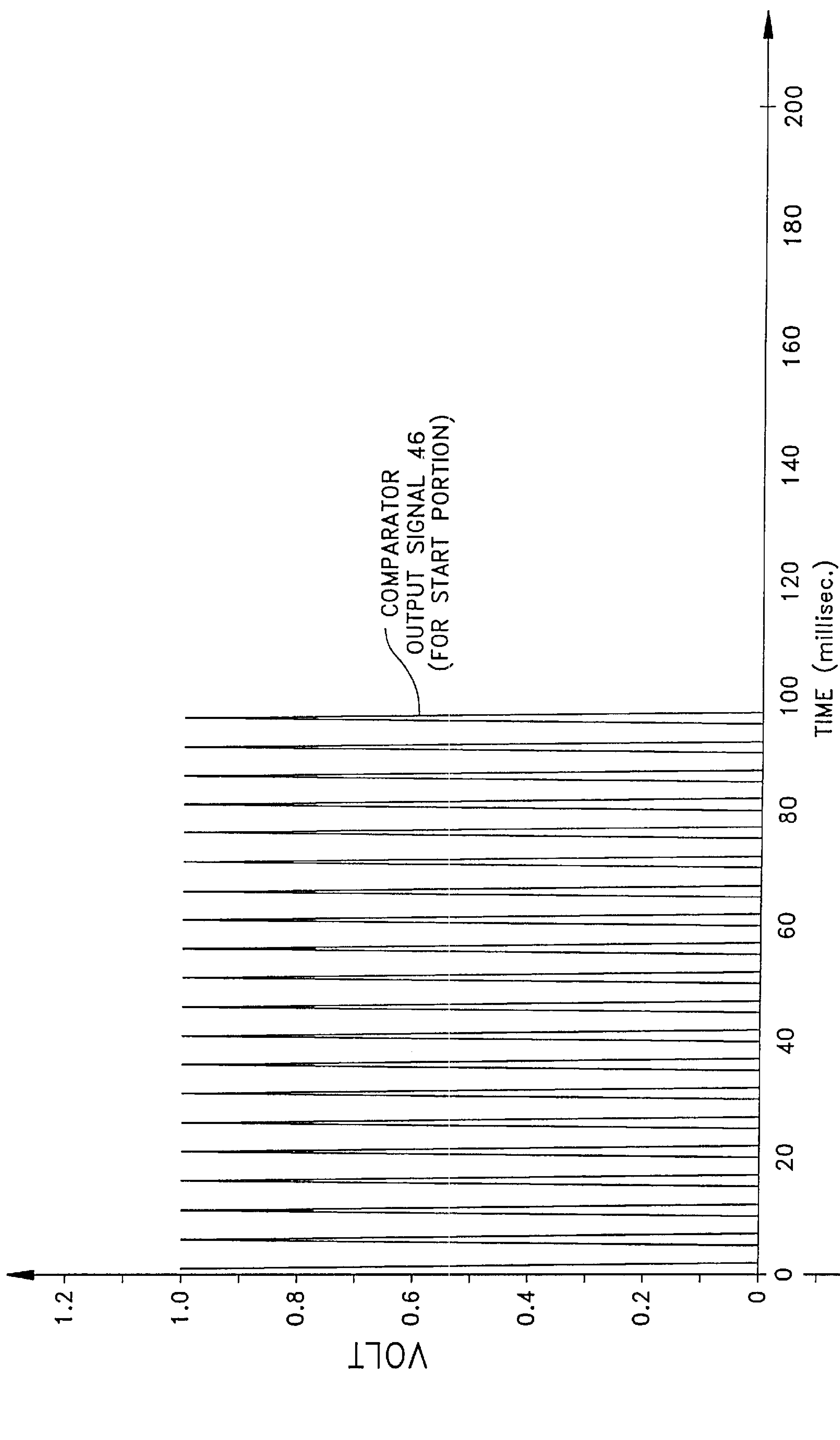

COMPARATOR
OUTPUT SIGNAL 46
(FOR START PORTION)
TIME (millisec.)
0
20
40
60
80
100
120
140
160
180
200
VOLT
1.2
1.0
0.8
0.6
0.4
0.2
0
-0.2

Fig.4

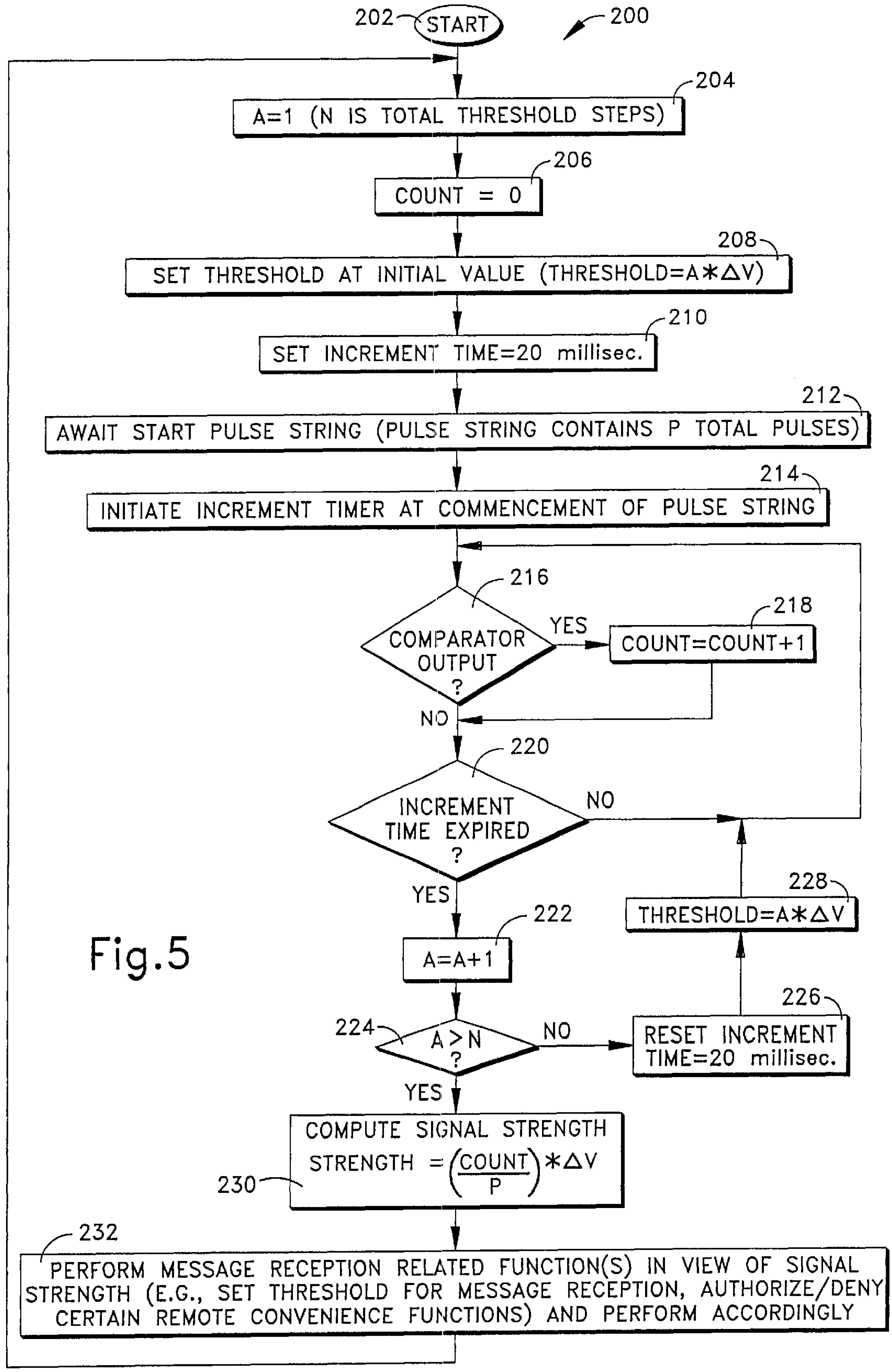

202
START
200
204
A=1 (N IS TOTAL THRESHOLD STEPS)
206
COUNT = 0
208
SET THRESHOLD AT INITIAL VALUE (THRESHOLD=A∗ΔV)
210
SET INCREMENT TIME=20 millisec.
212
AWAIT START PULSE STRING (PULSE STRING CONTAINS P TOTAL PULSES)
214
INITIATE INCREMENT TIMER AT COMMENCEMENT OF PULSE STRING
216
COMPARATOR OUTPUT ?
YES
218
COUNT=COUNT+1
NO
220
INCREMENT TIME EXPIRED ?
NO
YES
222
A=A+1
228
THRESHOLD=A∗ΔV
226
RESET INCREMENT TIME=20 millisec.
224
A>N ?
NO
YES
COMPUTE SIGNAL STRENGTH
STRENGTH = (COUNT/P)∗ΔV
230
232
PERFORM MESSAGE RECEPTION RELATED FUNCTION(S) IN VIEW OF SIGNAL STRENGTH (E.G., SET THRESHOLD FOR MESSAGE RECEPTION, AUTHORIZE/DENY CERTAIN REMOTE CONVENIENCE FUNCTIONS) AND PERFORM ACCORDINGLY

Fig.5

APPARATUS AND METHOD FOR REMOTE CONVENIENCE MESSAGE RECEPTION WITH SIGNAL STRENGTH DETERMINATION

FIELD OF THE INVENTION

The present invention relates to remote convenience systems, and is particularly directed to systems that have an ability to determine signal strength.

BACKGROUND OF THE INVENTION

Remote convenience systems are known in the art. Such remote convenience systems permit remote control of certain functions. One example type of a remote convenience system is for remotely controlling vehicle functions. Other example types of remote convenience systems include garage door opener systems and entry light activation systems. Focusing on the remote convenience vehicle systems, remotely controlled vehicle functions include locking and unlocking functions of one or more vehicle doors. A remote convenience system that permits remote locking and unlocking is commonly referred to as a remote keyless entry system. Such remote convenience vehicle systems may provide for control of other vehicle functions. For example, a remote vehicle locator function may be provided. The vehicle locator function causes a horn to emit a horn chirp and/or the headlights of the vehicle to flash "ON". This allows a person to quickly locate their car within a crowded parking lot.

Known remote convenience vehicle systems include a receiver/controller unit mounted in an associated vehicle and at least one portable hand-held transmitter unit located remote from the receiver/controller unit. Each transmitter unit is provided with one or more manually actuatable switches. Each switch is associated with a vehicle control function to be performed. The transmitter unit includes circuitry that responds to the actuation of one of the switches to transmit a function request message, along with a security code, in the form of a digital signal. A signal that is received by the receiver/controller unit is processed such that the vehicle performs the requested function.

The remote convenience systems operate in the ultrahigh frequency (UHF) portion of the radio frequency (RF) spectrum. Specifically, the signals from the transmitter units are in the UHF portion of the spectrum that is allocated by the United States Federal Communications Commission (FCC) for unlicensed transmission devices. FCC regulations stipulate that such unlicensed devices cannot have a transmitted signal strength that exceeds a preset maximum. Some countries other than the United States only permit very low levels of transmitted power. The transmitted power level in these countries is lower than the permitted level in the United States. For example, in Japan, remote convenience transmitter units have typical transmission power levels 30 dB below that of a typical United States remote convenience transmitter unit. In addition, within the United States, FCC regulations stipulate that the unlicensed devices must not cause undo radio interference and must operate despite the presence of any radio interference.

Often, it is desirable to accomplish remote control performance of certain functions at a longest possible distance. One example of such a function that is to be performed at the longest possible distance is the remote vehicle locator function. To illustrate such a scenario, consider a shopping mall patron exiting a shopping mall building and being faced with the task of visually locating their car within a vast shopping mall parking lot. It is beneficial to be able to actuate the remote vehicle locator function from a location near the exit door of the shopping mall, before proceeding into the parking lot.

Another example of a remote function that is to be performed at a longest possible distance is the door lock function. Thus, if an operator has forgotten to lock the vehicle doors and has proceeded away from the vehicle, the doors can be locked without returning to the vehicle.

For some remote control functions, it is desirable to permit performance only when the operator is relatively near the vehicle. One example of a remote function that is to be performed only when the operator is near to the vehicle is the door unlock function. Thus, the vehicle is unlocked only when the operator is near enough to see activity that occurs at the vehicle.

Distance is related to received signal strength. Thus, by determining signal strength, appropriate control can be accomplished.

SUMMARY OF THE INVENTION

In accordance with one aspect, the present invention provides an apparatus for determining signal strength of a received electromagnetic signal comprised of a plurality of pulses that convey a remote convenience function request, and for causing performance of the requested function. A comparator has a first input for receiving an electrical signal with a voltage that varies to convey the remote convenience function request. A second input of the comparator receives a threshold voltage value. An output of the comparator provides an output signal indicative of the occurrence of the voltage of the electrical signal exceeding the threshold value. Means adjusts the threshold voltage value. Means monitors the output signal of the comparator during adjustment of the threshold voltage value to determine strength of the electromagnetic signal.

In accordance with another aspect, the present invention provides a method of determining signal strength of an electromagnetic signal, that is comprised of a plurality of pulses that convey a remote convenience function request and that is intended for causing performance of the requested function. An electrical signal, which has a voltage that varies to convey the remote convenience function request, is compared with a threshold voltage value. An output signal that is indicative of the occurrence of the voltage of the electrical signal exceeding the threshold value is output. The threshold voltage value is adjusted. The output signal is monitored during adjustment of the threshold voltage value to determine strength of the electromagnetic signal.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other features and advantages of the present invention will become apparent to those skilled in the art to which the present invention relates upon reading the following description with reference to the accompanying drawings, wherein:

FIG. **1** is a schematic illustration of a remote convenience vehicle system that has components in accordance with the present invention;

FIG. **2** is a schematic illustration of a receiver/controller unit of the system of FIG. **1**;

FIG. **3** is a plot of two inputs provided to a comparator of the receiver/controller unit of FIG. **2** during a start portion of a received signal;

FIG. **4** is a plot of an output of the comparator during the start portion; and

FIG. **5** is a flow chart for a process performed within the receiver/controller unit of FIG. **2**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A remote convenience vehicle system **10** is schematically shown in FIG. **1**. The system **10** includes a transmitter unit **12** and an associated receiver/controller unit **14** that is mounted in a vehicle **16**. The transmitter unit **12** is operable to communicate, via an electromagnetic signal **18**, with the receiver/controller unit **14** to achieve remote control performance of at least one convenience function (e.g., unlock doors) at a vehicle system **20** (e.g., vehicle door lock actuator) of the vehicle **16**. The transmitter unit **12** is operated when it is desired to cause performance of the requested remote convenience function at the vehicle **16**.

The transmitter unit **12** is a portable hand-held unit with a housing that encloses its electronic components. The transmitter unit **12** includes at least one manually actuatable pushbutton electric switch. In the example shown in FIG. **1**, there are three pushbutton selector switches **24–28**. A first pushbutton switch **24** and a second pushbutton switch **26** are associated with door lock and unlock functions, respectively. A third pushbutton switch **28** is associated with a vehicle alarm or "panic" function. It will be appreciated that the system **10** could be configured to control different remote convenience functions (e.g., vehicle locate), and that the transmitter structure (e.g., the number, type, and the location of the pushbutton switches on the transmitter) would be accordingly different.

Each actuation or predefined series of actuations, of one of pushbutton switches (e.g., **24**) of the transmitter unit **12** is a request to perform a corresponding predefined remote convenience function. For example, actuating pushbutton switch **24** is a request to lock the doors of the vehicle **16**. The pushbutton switches **24–28** are operatively connected to a transmit radio frequency (RF) circuitry **32** within the housing of the transmitter unit **12**. The transmit RF circuitry **32** is, in turn, operatively connected to a broadcast transmission antenna **34**.

In response to pushbutton actuation, transmit RF circuitry **32** generates/assembles a "packet" of information to be transmitted. The transmission packet includes a start/wake-up portion, a security code, and at least one command that represents the remote function request. The transmit RF circuitry **32** then provides an appropriate electrical signal **36** that conveys the transmission packet to the antenna **34**. In response to the stimulus of the electrical signal **36**, antenna **34** broadcasts the signal **18**, which is intended to be received by the receiver/controller unit **14** at the vehicle **16**. Preferably, the transmitted signal **18** is a pulse-width-modulated (PWM) signal that has a radio frequency (RF) carrier frequency. It is to be appreciated that other signal types (e.g., frequency modulation, and frequency shift key) can be used without deviating from the present invention.

Within the receiver/controller unit **14**, an antenna **40** is operatively connected to a receiver portion **42**. The antenna **40** provides a RF electrical signal **44** that conveys the contents (e.g., a security code and a function request message) of the transmitted signal **18** that has been received. The receiver portion **42** processes the conveyed information and provides a signal **46** to a controller portion **48**. Specifically, in one preferred embodiment, the receiver portion **42** includes an amplifier, a mixer that beats the signal with a local oscillator signal, a buffer, and a bandpass filter. Thus, the signal **44** is converted to an intermediate or baseband frequency having a plurality of pulses. Each pulse has amplitude that is dependent upon the strength of the transmitted signal **18**.

Within the controller portion **48**, the information-conveying pulses are processed by a microprocessor **52** (FIG. **2**) to determine if the transmitted signal **18** includes a proper security code and to determine the function that is requested. If the transmitted signal **18** includes the proper security code, the controller portion **48** provides an appropriate signal **50** to the corresponding vehicle system **20** (e.g., door lock actuator system) to cause performance of the requested function.

With regard to the convenience functions that are remotely controlled via the system **10** (FIG. **1**), the person of ordinary skill in the art will understand the vehicle system(s) **20** and the operation of such functions, as they are known in the art. Also, the person of ordinary skill in the art will understand the processing of the information regarding security code and function request message portions by the microprocessor **52** (e.g., decoding). Accordingly, detailed descriptions of such systems and functions are not provided herein for brevity. Also, it will be appreciated that the present invention is applicable to other non-automotive, remotely controlled functions (e.g., garage door opening or entry light activation).

Within the receiver portion **42**, the RF signal **44** provided from the antenna **40** is converted to a lower frequency in order to permit processing. Accordingly, the receiver portion **42** includes carrier frequency processing circuitry **54** (FIG. **2**). In one example, the carrier frequency processing circuitry **54** includes a front-end amplifier **56** that receives the RF signal **44** that is output from the antenna **40**. A signal **58** output from the amplifier **56** is provided as a first input to mixer **60**. A local or reference oscillator **62** provides an oscillating signal **64** at a reference frequency as a second input to the mixer **60**.

The mixer **60** combines the two input signals and outputs a signal **66** that has frequency component values that are at the sum and difference of the frequency values of the two input signals. In other words, the mixer **60** "beats" the first input signal **58** with the second input signal **64**. The "difference frequency" value is at the IF frequency.

The carrier frequency processing circuitry **54** includes a buffer **68**, a bandpass filter **70**, and an amplifier **72** for handling the IF frequency signal output from the mixer **60**. The buffer **68** receives the signal **66** output from the mixer **60**, and provides an output **74** to the bandpass filter **70**. The bandpass of the filter **70** is centered on the IF frequency. Thus, other frequency components, such as the "sum frequency" produced in the mixer **60**, are removed. The amplifier **72** amplifies a signal **76** output from the filter **70**, and provides an IF signal **78**, which is the output from the carrier frequency processing circuitry **54** and provided to a first node **80**.

It is to be appreciated that the signal **78** is comprised of a series of pulses that convey the contents (e.g., start portion, security code, function request) of the transmitted signal **18**. Each pulse of the signal **78** has amplitude that is dependent upon signal strength. Preferably, amplitude is represented by voltage amplitude.

FIG. **3** is an example of a plot of a portion of the signal **78**. The signal portion happens to correspond to a start portion of the transmitted signal **18**. Pulse amplitude happens to be 0.6 volts.

The signal **78** (FIG. **2**) output from the carrier frequency processing circuitry **54** must be further processed to differentiate between pulses that convey information and pulses that are the result of noise and the like. Also, this further processing permits transmitted signals **18** that have insufficient strength to be ignored by the receiver/controller unit **14**. Thus, only pulses that meet certain criterion are passed alone to the controller portion **48** for decoding, etc. The criterion used to screen-out certain pulses is adjustable and is provided by the structure set forth below.

In particular, the structure for the further processing is a comparator **82**, whose output is the signal **46**. The first node **80** is connected to a first input terminal of the comparator **82**, and the signal **78** is provided as a first input to the comparator. A second node **84** is connected to a second input terminal of the comparator **82**, and a reference voltage is supplied as a second input signal **86** to the comparator. In the plot of FIG. **3**, a voltage value trace is shown for the signal **86**. The voltage happens to change over the course of time. This changing voltage value of the signal is explained below.

When the voltage amplitude of the first input signal **78** is greater than the voltage amplitude of the second input signal **86**, the output signal **46** of the comparator **82** is a HIGH (e.g., 1.0 volt as is shown in an example plot of FIG. **4**). The duration of the HIGH is dependent upon the time that the input pulse voltage of the signal **78** (FIG. **2**) exceeds the reference voltage of the signal **86** (i.e., generally equal to the duration of the pulse of the first input signal **78**). When the voltage amplitude of the first input signal **78** is less than the reference voltage of the second input signal **86**, the output signal **46** of the comparator **82** is LOW. Thus, the reference voltage is a threshold value. FIG. **4** is a plot of the output signal **46** of the comparator **82** for the two inputs plotted in FIG. **3**. At this point it is sufficient to note that the output pulses occur only when the voltage value of the input pulses (signal **78**) exceed the threshold voltage value (signal **86**). The significance of the cessation of the output pulses shown in FIG. **4** is discussed below.

The reference voltage at the second node **84** (FIG. **2**) is the voltage across a capacitor **88** that is connected between the second node and electrical ground. Electrical energy is supplied to the second node **84** by a regulated voltage source voltage source Vcc (e.g., a battery of the vehicle **16** and regulation circuitry) connected to the second node **84** via a resistor **90**. The first and second nodes **80** and **84** are connected together via a resistor **92**.

A microprocessor **100** is provided. The microprocessor **100** has the capability to either draw current from or supply current to the second node **84**. The microprocessor **100** is connected, via a line **102**, to the second node **84** to monitor the reference voltage. A current-supply terminal **104** of the microprocessor **100** is connected to the second node **84** via a diode **106** and a resistor **108**. A current-sink terminal **110** of the microprocessor **100** is connected to the second node **84** via a diode **112** and a resistor **114**. Thus, the reference voltage of the second input signal **86** is controlled by the microprocessor **100**. The current flow between the microprocessor **100** and the second node **84** can maintain the reference voltage at a desired level.

The current flow between the microprocessor **100** and the second node **84** can also change (increase or decrease) the reference voltage to a new level. Decreasing the reference voltage results in a weaker signal (i.e., with lower amplitude pulses) being permitted to "pass" the comparator **82**. Increasing the reference voltage results in the opposite effect. This provides an ability to "accept" certain signals and to "ignore" other certain signals, dependent upon signal strength.

The strength of the transmitted signal **18** (FIG. **1**) that is received at the receiver/controller unit **14** is dependent upon the distance between the transmitter unit **12** and the receiver/controller unit. The receiver/controller unit **14** can determine the strength of the transmitted signal **18** in accordance with the present invention. Determination of signal strength is useful to permit differentiation between whether a requested function, conveyed via the transmitted signal **18**, will be performed or ignored.

The determination regarding signal strength is made during a start portion of the transmitted signal **18**. The results of the strength determination are utilized during subsequent portions of the transmitted signal **18** (i.e., the security code and function request message portions).

The start portion includes a series of pulses that are identical and periodic. The start portion exists for a predetermined duration and each of the pulses exists for a predetermined duration. Accordingly, a predetermined number of pulses occur during the start portion. FIG. **3** illustrates a plot of an example of the signal **78** that is output from the carrier frequency processing circuitry **54** for the portion of time corresponding to the start portion. In the example of FIG. **3**, the start portion exists for two-hundred (200) milliseconds and forty (40) pulses are provided within the start portion.

For any given distance between the transmitter unit **12** and the receiver/controller unit **14**, the pulses of the signal **78** output from the carrier frequency processing circuitry **54** all have a given voltage value. In the example shown in FIG. **3**, the pulses have a voltage value of 0.6 volts. In order to make the determination regarding signal strength, the receiver/controller unit **14** makes a determination of the voltage value of the signal **78**.

As part of the structure for making the signal strength determination, the controller portion **48** includes an increment timer **120** and a threshold change trigger **122**. The increment timer **120** is capable of timing relatively short time periods that exists for some duration less than the overall duration of the start portion of the transmitted signal **18**. In the illustrated embodiment, the increment timer **120** is adapted to repeatedly decrement 20 millisecond durations.

The threshold change trigger **122** is operatively connected to the microprocessor **100** and communicates **124** with the microprocessor **100** during the start portion of the transmitted signal **18**. For each timed duration provided by the increment timer **120**, the threshold change trigger **122** causes the microprocessor **100** to provide one of a plurality of voltage level "steps" as of the threshold voltage at the second input signal **86**. As each timed duration expires, the threshold change trigger **122** causes the microprocessor **100** to increase the threshold voltage to a next step. In the shown embodiment (see FIG. **3**), the difference between each threshold voltage step is 0.1 volts. Accordingly, during the course of the start portion of the transmitted signal **18**, the threshold voltage is stair-stepped from 0.1 volts to 1 volt, with each step coming at 20 millisecond intervals.

A count memory **126** (FIG. **2**) is operatively connected to the microprocessor **52** of the controller portion **48** for counting output pulses (FIG. **4**) that are seen by the microprocessor **52** in the output signal **46** of the comparator **82** during the start portion. The output pulses will occur so long as the pulses of the signal **78** exceed the threshold voltage at the second input signal **86**. Thus, at some point during the start portion of the transmitted signal **18**, the threshold voltage will be stepped up sufficiently high to exceed the voltage value of the pulses at the signal **78** and the output of the comparator **82** will be a steady state LOW.

The number of counted output pulses during the stair-stepping threshold change for the start portion is indicative of the strength of the transmitted signal **18**. Specifically, the relative signal strength is related to:

$$\text{strength}=(\text{count}/p)*\Delta v$$

where:

count=number of comparator output pulses;

p=number of pulses in the start portion; and

Δv=voltage change increment for threshold voltage value.

In the illustrated example, there are forty (40) pulses during the start portion, and the threshold increment (Δv) is 0.1 volts. As shown by FIG. **4**, the comparator **82** provides twenty (20) output pulses. Thus, the relative strength of the transmitted signal **18** in the example is:

$$\text{strength}=(20/40)*\ 0.1$$

strength=0.05

The controller portion **48** can then use the relative strength value to process and/or control the operation within the receiver/controller unit **14** for the rest of the transmitted signal that is to be received (i.e., the security code and the remote function request).

In one example, the controller portion **48** can cause the microprocessor **100** to adjust the threshold voltage value such that the rest of the transmitted signal will be effectively ignored by raising the threshold voltage value. As an alternative, the controller portion **48** can authorize or ignore certain functions based upon logic within the controller portion. For example, if the microprocessor **52** determines that the received function request is to unlock the vehicle doors, the microprocessor commands (authorizes) unlocking of the vehicle doors only if sufficient signal strength has been detected via the start portion of the transmitted signal **18**. As another example, if the received function request is to lock the vehicle doors, the microprocessor commands (authorizes) locking of the doors regardless of the detected signal strength.

The precision with which the signal strength is determined during the start portion of the transmitted signal **18** is dependent upon the size of the threshold voltage change step (e.g., 0.1 volts), and the number of pulses within the start portion pulse string. Specifically, based upon the equation:

$$\Delta v^{*P}/_{M}=\text{maxvoltage}$$

where:

Δv=voltage change increment for the threshold;

p=number of pulses in the start portion;

m=maximum number of pulses that can occur during each threshold voltage step; and

maxvoltage=the maximum voltage that is achieved during voltage stepping.

If it is assumed that K=P÷M, then K is the maximum number of steps to reach the maximum voltage level. Accordingly, reducing the size of the change in threshold voltage and shortening the length of each incremental time duration will result in an increase in the ability to determine exact signal strength.

FIG. **5** is an example of a process **200** performed within the controller portion **48**. The process **200** is initiated at step **202** and proceeds to step **204**, where a variable "A" is set equal to 1. The total number of threshold steps is "N". At step **206**, a variable "count" is set equal to zero (0). At step **208**, the threshold value is set equal to an initial value (i.e., the threshold value is equal to "A" multiplied by the threshold increment, Δv). In the illustrated example, the threshold increment Av is 0.1 volts and the initial threshold value is 0.1 volts. The increment timer **120** is set to 20 milliseconds in step **210**.

At step **212**, the receiver/controller unit **14** awaits the beginning of the start portion of the transmitted signal **18**. It is to be recalled that the pulse string of the start portion contains "p" total pulses. As soon as the start portion begins (i.e., the receiver/controller unit **14** receives the very first pulse indicating the beginning of the transmitted signal **18**), the increment timer **120** is initiated at step **214**. At step **216**, it is determined whether the comparator **82** provides an output pulse. Since the threshold value is set initially low, the comparator **82** will output a pulse and the determination at step **216** is affirmative.

Upon the affirmative determination at step **216** (i.e., an output pulse occurs), the process **200** goes to step **218** in which the "count" value in the count memory **126** is increased by one (1). Upon completion of step **218**, the process **200** goes to step **220**. It should be noted that if the determination at step **216** is negative (i.e., the comparator **82** does not output a pulse), the process **200** goes directly from step **216** to step **220**.

At step **220**, it is determined whether the time duration, which is being decremented by the increment timer **120**, has expired. If the determination at step **220** is negative (the time has not yet expired), the process loops from step **220** to step **216**, in which it is again determined whether the comparator **82** has output a pulse. The process **200** continues to loop through steps **216**–**220** for the duration of the increment time period. Each pulse of the output signal **46** from the comparator **82** results in the value of the variable "count" increasing by one (1).

If the determination at step **220** is affirmative (i.e., the increment time has expired), the process **200** goes from step **220** to step **222**. At step **222**, the variable "A" is increased by one (1). The increase of "A" by one is utilized to step the threshold value to the next incremental level. Specifically, at step **224**, it is determined whether the value of "A" is greater than the value of "N"(i.e., whether "A" is greater than 10 in the illustrated example).

If the determination at step **224** is negative (i.e., "A" is less than "N" indicating that the stair-stepping of the threshold has not yet been completed), the process **200** goes to step **226** in which the increment time is reset to 20 milliseconds. The threshold voltage is set to the next increment. Specifically, the threshold is equal to value of "A" multiplied by the threshold increment Av (i.e., A×0.1 volts). From step **228**, the process **200** goes to step **216**. Thus, the process **200** continues in the nested loops provided by steps **216**–**228** until the stair stepping of the threshold voltage value is completed.

During the nested loops, the variable "count" continues to increase for each pulse in the output signal **46** of the comparator **82**. However, at some point during the stair stepping, the threshold value will be increased such that the comparator **82** does not output any pulses. At that point in time, the variable "count" will not be increased for the rest of the stair stepping of the threshold value.

Upon an affirmative determination at step **224** (i.e., the stair-step incrementing is completed), the process **200** goes from step **224** to step **230**. At step **230**, the signal strength is computed. At step **232**, the microprocessor **52** within the controller portion **48** performs message reception related functions in view of the determined signal strength. For example, the microprocessor **52** may authorize or ignore certain remote convenience function requests dependent upon the determined signal strength. Upon complete of step **232** (i.e., upon completion of reception of the transmitted signal **18** and appropriate action thereupon), the process **200** again returns to step **204**. Steps **204–212** are performed and the next transmitted signal **18** is awaited at step **212**.

From the above description of the invention, those skilled in the art will perceive improvements, changes an d modifications. Such improvements, changes and modifications within the skill of the art are intended to be covered by the appended claims.

Having described the invention, the following is claimed:

1. An apparatus for determining signal strength of a received electromagnetic signal comprised of a plurality of pulses that convey a remote convenience function request, and for causing performance of the requested function, said apparatus comprising:

a comparator having a first input for receiving an electrical signal with a voltage that varies to convey the remote convenience function request, a second input for receiving a threshold voltage value, and an output for providing an output signal indicative of the occurrence of the voltage of the electrical signal exceeding the threshold value;

means for adjusting the threshold voltage value; and

means for monitoring the output signal of the comparator during adjustment of the threshold voltage value to determine strength of the electromagnetic signal;

wherein the output signal of said comparator has a pulse for each occurrence of the voltage of the electrical signal exceeding the threshold value, said means for monitoring includes means for counting the pulses of the output signal.

2. An apparatus as set forth in claim **1**, including means for calculating strength of the electromagnetic signal using the counted pulses.

3. An apparatus as set forth in claim **2**, wherein the electromagnetic signal has a start portion, the start portion has a predetermined number of pulses and exists for a predetermined duration, the predetermined duration is divided into a plurality of time increments, said means for adjusting includes means for increasing the threshold voltage value by a predetermined amount at an end of every time increment.

4. An apparatus as set forth in claim **3**, wherein within said means for calculating, the signal strength is based upon:

$$\text{strength}=(\text{count}/p)*\Delta v$$

where:

count=number of comparator output pulses;

p=number of pulses in the start portion; and

Δv=incremental change in threshold.

5. A method of determining signal strength of an electromagnetic signal, that is comprised of a plurality of pulses that convey a remote convenience function request and that is intended for causing performance of the requested function, said method comprising:

a comparing an electrical signal, that has a voltage which varies to convey the remote convenience function request, with a threshold voltage value;

outputting an output signal indicative of the occurrence of the voltage of the electrical signal exceeding the threshold value wherein the output signal has a pulse for each occurrence of the voltage of the electrical signal exceeding the threshold voltage value;

adjusting the threshold voltage value; and

monitoring the output signal during adjustment of the threshold voltage value to determine strength of the electromagnetic signal wherein the step of monitoring the output signal includes the step of counting the pulses of the output signal.

6. An apparatus for determining signal strength of a received electromagnetic signal and for providing a strength signal indicative of the determined signal strength of the received electromagnetic signal, said apparatus comprising:

a comparator having a first input for receiving an electrical signal, a second input for receiving a threshold voltage value, and an output for providing an output signal indicative of the occurrence of the voltage of the electrical signal exceeding the threshold voltage value, the output signal of said comparator having a pulse for each occurrence of the voltage of the electrical signal exceeding the threshold value;

means for adjusting the threshold voltage value; and

means for monitoring the output signal of the comparator during adjustment of the threshold voltage value to determine signal strength of the electromagnetic signal, said means for monitoring including means for counting the pulses of the output signal and means for providing a strength signal indicative of the signal strength of the electromagnetic signal in response to the counted pulses.

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